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# Groundwater Concentration of Trace Elements in Gbede Area of Oyo State, Nigeria

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**Abstract**

The availability of good quality water is indispensable feature for preventing diseases and improving quality of life. The study area, Gbede is located between latitude 8˚17'37.7" and 8˚17'49.8'' North and between Longitude 4˚20'45.9'' and 4˚20'58.8 East on Old road from Ogbomoso to Ilorin. Water samples from eleven shallow well, one deep well and two boreholes were analyzed using the Atomic Absorption Spectrophotometer to access the suitability of water for human consumption and domestication purposes. The selected trace metals iron, manganese, lead, silicon and cadmium which may be toxic in excess when present in drinking water were determined. The results obtained for the trace metals concentrations range from iron (1.38-1.65mg/L) with an average of 1.52mg/L, manganese (0.6-1.46mg/L) having an average of 1.03mg/L, lead (0.3-1.8mg/L), 1.05mg/L on average, silicon (10-14mg/L) with 12mg/L on average, and cadmium (0.31-0.32mg/L) with 0.32mg/L average respectively. Iron and cadmium exceeded the World Health Organization (WHO) Standard guideline for portable water usage. The result reflects high pollution of iron and cadmium which may be associated with lateritic rocks present in the study area. It is therefore recommended that for a safe and quality water, a treatment process must be introduced in the area.

***Keywords:*** Total hardness; Iron; Physico-chemical; laterictic rocks; pollution.

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## 1. Introduction

Water indeed is an essential component of life [1]. The need for water in the day to day activities of man include for cooking, washing, drinking and for industrial activities [2]. Water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand more water of high quality for domestic purposes and economic activities. Water sources, ranging from atmospheric to ground water, do have different pollution sources due to the differences in their mode of existence, exposure to environmental hazards/pollutants and consequent harvesting techniques.

Water abstraction for domestic use, agricultural production, mining, industrial production, power generation, and forestry practices can lead to deterioration in water quality and quantity that impact not only the aquatic ecosystem (i.e., the assemblage of organisms living and interacting together within an aquatic environment), but also the availability of safe water for human consumption. Ground water is an important source of drinking water for humankind, it contains over 90% of the fresh water resources and it is an important reserve of good quality water.

Access to safe drinking water is a problem facing a large proportion of the inhabitant of the developing nations [3-5]. In spite of the considerable investments of Nigerian government in water supply programme, over 52% of its population has no access to potable water [6]. Consequently, the inhabitants have resulted into the use of hand-dug wells as an alternative source of water supply. Hand-dug wells also provide cheap and low-technology solution to the challenges of rural and urban water supply. Well construction too affords an opportunity for community participation during all phases of the water supply process [7].

The water pollution by heavy metals has become a question of considerable public and scientific concern in the light of the evidence of their toxicity to human health and biological systems [8]. Heavy metals receive particular concern considering their strong toxicity even at low concentrations [9]. They exist in water in colloidal, particulate and dissolved phases [10] with their occurrence in water bodies being either of natural origin (e.g. eroded minerals within sediments, leaching of ore deposits and volcanism extruded products) or of anthropogenic origin (i.e. solid waste disposal, industrial or domestic effluents) [9]. Some of the metals are essential to sustain life; calcium, magnesium, potassium and sodium must be present for normal body functions. Also, cobalt, copper, iron, manganese, molybdenum and zinc are needed at low levels as catalyst for enzyme activities [10].

Metals in water can pose serious threats to human health. In particular, arsenic, a semi-metallic element which occurs naturally in some surface and ground water sources, may lead to development of skin lesions and cancer in people exposed to excess concentrations through drinking water, bathing water, or food. Arsenic can be mobilized from host minerals through anaerobic microbial respiration (i.e., bacteria that are able to respire in the absence of oxygen), as long as sufficient organic carbon is available to sustain metabolism. This study was aimed at analyzing the concentration of trace element present in groundwater of Gbede area in comparison with [11] standards for drinking purposes.

In Nigeria, majority of the rural populace do not have access to potable water and therefore, depend on shallow well, stream and river water for domestic use. The bacterial qualities of groundwater, pipe borne water, and other natural water supplies in Nigeria have been reported to be unsatisfactorily, with coliform count far exceeding the level recommendation by W.H.O [12-14].Parameters for drinking water quality typically fall under two categories: chemical/physical and microbiological [15-17]. Chemical/physical parameters include heavy metals, trace metals, total suspended solids (TSS) and turbidity. There are varieties of trace elements present in virtually all potable water, some of which play a role in metabolism. Major ions in drinking water are correlated with palatable and unpalatable mineralization that affects the quality of drinking water [18-19]. $SO_4^{2-}$ makes water taste unpalatable by decreasing the concentration of $Ca^{2+}$, which are essentials for good tasting water while Element such as Fe, Ni, Zn etc. are essential for growth [20].

### *1.1 Description of the Study Area*

The study area is in Surulere LGA in Oyo State, Southwestern Nigeria. It is an area that is visually made of lateritic rocks. It is accessible through Ogbomoso-Gambari-Ilorin Old road. The population of the area is less than 5000 based on available statistics, and the people are predominately farmers and transporters. The major sources of water supply in the area are groundwater which is obtained majorly from shallow wells (within the range of 5 m), deep well, boreholes. Most residents in the area use pit latrines and waste disposal is indiscriminately carried out.

### *1.2 Geology of the Study Area*

Regionally, the study area lies within the Southwestern part of the basement rocks, which is part of the much larger Pan- Africa mobile belt that lies In- between the West African Craton and Congo Craton, suspected to have been subjected only on a thermotectonic event [21].

The study area is located between latitude 8˚17’37.7” and 8˚17’49.8’’ North and between longitude 4˚20’45.9’’ and 4˚20’58.8 East.

The local geology of the study area (Figure 1) consist of migmatite-gneiss, migmatite is a rock that is a mixture of metamorphic rock and igneous rock.

It is created when a metamorphic rock such as gneiss partially melts, and then re-crystallizes into an igneous rock, creating a mixture of the unmelted metamorphic part with the re-crystallized igneous part.

They can also be known as diatexite. Migmatites form under extreme temperature conditions during prograde metamorphism, where partial melting occurs in pre-existing rocks. Migmatites are not crystallized from a totally molten material, and are not generally the result of solid-state reactions.

Commonly, migmatites occur within extremely deformed rocks that represent the base of eroded mountain chains, typically within Precambrian cratonic blocks. Precambrian rocks are typical for the basement complex of Nigeria [22].

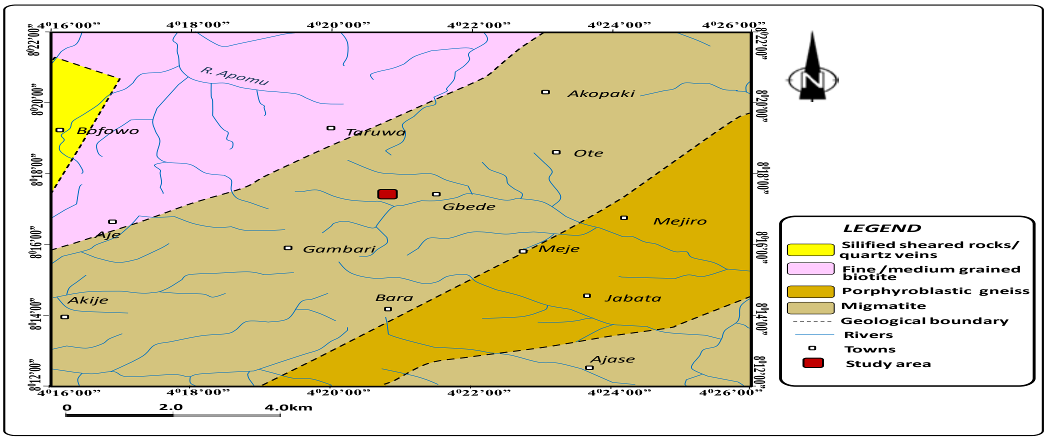


**Figure 1:** Geological map showing the rock type underlining the study area, adapted after [23]

## 2. Materials and Methods

### *2.1 Samples Collection*

A total of 14 water samples were collected with different proximity to majorly concentrated lateritic rocks within Gbede village. Before the sampling, the bottles were washed thoroughly with detergent, acids, tap water and then distilled water. The chemical parameters were determined by using standard methods immediately after taking them into the laboratory. The sample was acidified with 1% nitric acid to discourage the formation of precipitates and to keep the metal ions in the dissolved state). The water sources were categorized as shallow wells (11), deep well (1) and bore holes (2) while the average depth of the shallow wells is 5 m from the investigation through the Vertical Electrical Sounding survey conducted during the dry season of the year, i.e. January - February.

### *2.2 Samples Preparation and Analysis*

De-ionised water was used throughout the analysis wherever applicable. Total hardness was determined using standard EDTA titration with ammonia buffer and black T-indicator. Alkalinity was determined by strong acid titration method. Turbidity and pH were determined using the method of [24]. Thereafter, trace elements of interest (Iron, Manganese, Lead, Silicon and Cadmium) were determined using Varian AA240FS Atomic Absorption Spectrophotometer All the analyses were carried out at the laboratory within the twenty-four (24) hours of collection for physicochemical analysis. The results obtained for various analyses were compared with the World Health Organization (WHO) standard specified for drinking water as shown in Table 1 for concentration values, logarithmic values of concentration in Figure 2 and average values of concentration in figure 3 respectively.

## 3. Results and Discussions

### *3.1Iron*

Iron is an essential element in human nutrition. The estimates of the minimum daily requirement for iron depend on age, physical status, sex and bio-availability; its range is from about 10-50mg/day. The primary sources of iron are ferromagnetic minerals. Domestic· and industrial supplies need to be monitored for presence of iron. In domestic use, the presence of iron affects taste of beverages and imparts brownish colour to plumbing fixtures and clothes. Corrosion and encrustation problem is also associated with iron present in water. The concentration of iron in all the samples from Gbede are higher than the WHO and Bureau of Indian Standard (BIS) permissible limit of 0.3mg/l as shown in table 1 and Figure 2, while logarithm values displayed in figure 3 respectively. This may be attributed to the presence of iron ore in the study area. The concentrations measured were between 1.38 and 3.22mg/L. The high concentration of iron in this sample may discoloured and increase the turbidity of the water from the sample. Although iron has little concern as a health hazard but it is still considered as a nuisance when in excessive quantities. When water with high ironic concentration is used in preparation of tea and coffee, a black inky appearance with a metallic taste is given. The shortage of iron causes a disease called Anemia and prolong consumption of drinking water with high concentration of iron may lead to liver disease called Haermosiderosis.

### *3.2 Manganese*

Manganese concentrations normally found in drinking water does not constitute a health hazard. However, even small amount of manganese may impact objectionable tastes or blackish stain to water. As shown in table 1 and figure 2, the minimum and maximum concentration of Manganese metal ions obtained from the shallow wells, deep wells and borehole waters at the different samples range from 0.6 mg/L to 1.46mg/L. The maximum permissible limit by WHO is 0.1mg/L, the concentration of manganese metal ions on the average from all samples in Figure 3 were observed to be above the maximum permissible limit set by the world health organization.(WHO) for drinking water. All the water samples from this study area revealed manganese levels above the W.H.O limit. It should be noted that manganese may be objectionable to consumers if it is deposited in water mains and causes water discoloration. To make the water safe for drinking, oxidation treatment should be performed on the water to reduce the level of manganese in water.

### *3.3 Lead*

Lead is readily available to man as it is relatively common in earth's crust. Exposure of human beings to lead has been intensified by rapid industrialization and excessive use of fuel, batteries, and paints, among others. Lead can cause irreversible metabolic malfunctions in human body causing neurological defects. The insoluble nature of lead compounds in water makes its bioavailability restricted and as such may not cause any adverse effect to groundwater users. If lead is detected in drinking water, it probably originated from corrosion of plumbing system. The source of lead in drinking water may also be from ground water pollution rather than corrosion of the plumbing system. Aside the nervous disorders and mental impartment especially in foetus, infants and young children, high concentration of lead can also cause kidney damage, blood disorders and hypertension, low birth weights when it is consumed at high concentration. The acceptable limit from [25] is 15mg/L. However, the analytical results reveal that the concentration of both the minimum and the maximum value of lead in water samples ranges from 0.3mg/L to 1.8mg/L in table 1 and figure 2 which are still within the acceptable limit.. This is also complemented with figure 3 for the average value of concentration.

### *3.4 Silicon*

Silicon is the second most abundant element in nature. Silica concentration in water is commonly less than 30mg/L, although concentrations greater than 100mg/L are not unusual, concentration exceeding 1000mg/L are possible in brines and brackish water. The silicon concentrations in the study area was found to be in the range of 10 mg/l – 14 mg/l for minimum and maximum values as indicated in Table 1 and Figure 2. This trend is also noticeable in figure 3 depicting the average values of concentration which is less than 30mg/L, i.e. the WHO limit.

### *3.5 Cadmium*

Cadmium is classified as toxic trace element. It is found to be associated with ores of lead, lead-zinc and lead-zinc-copper. Cadmium exerts its toxic effect by adversely altering various biochemical reactions and pathological processes in the body, including testicular neurosis and tumors, renal dysfunction, hypertension, arteriosclerosis, growth inhibition, chronic disease of old age, and damage to central nervous system [26-27]. Minimum toxic or maximum safety dietary cadmium levels cannot be given with any precision because cadmium metabolism is influenced by zinc, copper, iron, selenium, and calcium. For drinking purposes, concentration up to 0.01mg/L can be tolerated, whereas the concentration of cadmium from the present study as contained in table 1 and figure 2 ranged between 0.31mg/l and 0.32mg/l which are above 0.005mg/l permissible limit as recommended by WHO. This is also evident in Figure 3 showing the average values of concentration. However suitable treatment should be recommended for the purpose of drinking.

**Table 1:** Concentrations of trace element and some physical parameters in the samples analyzed

| Samples | Type | pH | Alkalinity (mg/l) | TDS (mg/l) | Iron (mg/l) | Manganese (mg/l) | Lead (mg/l) | Silicon (mg/l) | Cadmium (mg/l) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | SW | 6.8 | 72 | 410 | 1.52 | 0.6 | 0.6 | 14 | 0.32 |
| 2 | BH | 6.8 | 72 | 412 | 1.4 | 0.98 | 0.3 | 12 | 0.32 |
| 3 | SW | 6.4 | 120 | 424 | 1.41 | 0.67 | 0.8 | 12 | 0.31 |
| 4 | SW | 6.3 | 120 | 430 | 1.39 | 0.7 | 0.9 | 10 | 0.31 |
| 5 | SW | 6.8 | 140 | 572 | 1.65 | 0.6 | 1.3 | 14 | 0.31 |
| 6 | SW | 6.7 | 180 | 682 | 1.4 | 1.46 | 1.1 | 10 | 0.31 |
| 7 | SW | 6.4 | 72 | 524 | 1.4 | 0.86 | 1.3 | 12 | 0.31 |
| 8 | SW | 6.9 | 100 | 424 | 1.39 | 0.59 | 1.6 | 10 | 0.31 |
| 9 | SW | 6.4 | 100 | 520 | 1.38 | 0.61 | 1.7 | 12 | 0.31 |
| 10 | SW | 7.1 | 140 | 435 | 1.7 | 0.59 | 1.8 | 12 | 0.31 |
| 11 | SW | 6.0 | 160 | 430 | 1.38 | 0.59 | 1.3 | 10 | 0.31 |
| 12 | DW | 5.2 | 140 | 424 | 1.4 | 1.05 | 1.7 | 14 | 0.31 |
| 13 | SW | 6.4 | 120 | 680 | 3.22 | 0.61 | 1.4 | 12 | 0.31 |
| 14 | BH | 6.9 | 78 | 524 | 1.37 | 0.74 | 0.8 | 10 | 0.31 |
| **Minimum** | | **5.2** | **72** | **410** | **1.37** | **0.46** | **0.3** | **10** | **0.31** |
| **Maximum** | | **7.1** | **180** | **682** | **3.22** | **1.46** | **1.8** | **14** | **0.32** |
| **W.H.O** | | **8.5** | **200** | **500** | **0.3** | **0.5** | **15** | **30** | **0.01** |

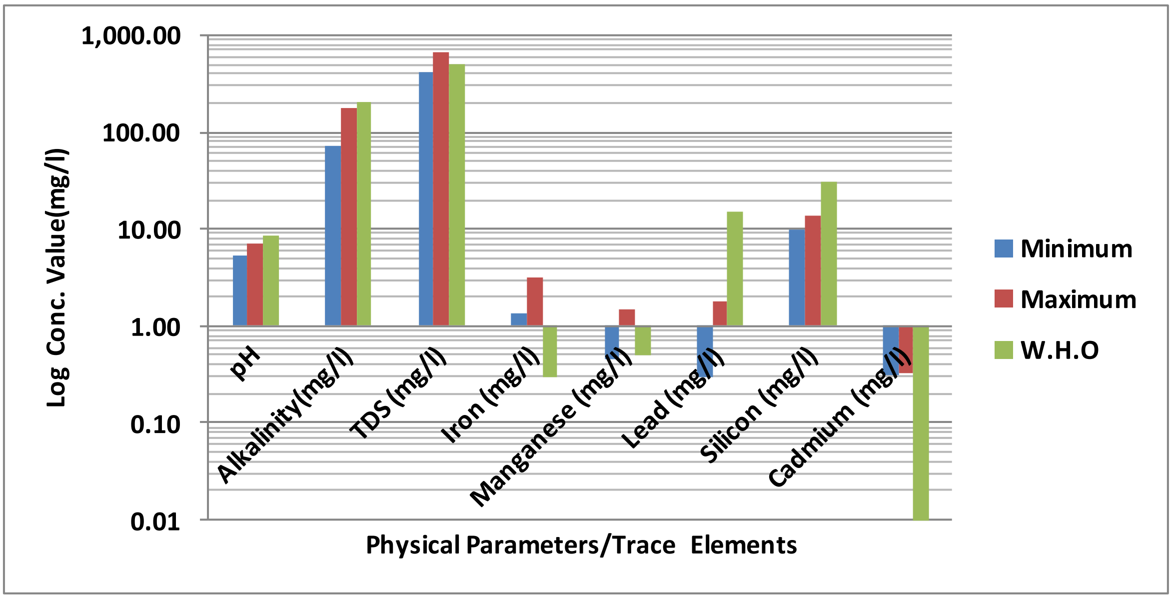


**Figure 2:** Comparative analysis of Log of minimum and maximum values concentration of water parameters with WHO standard

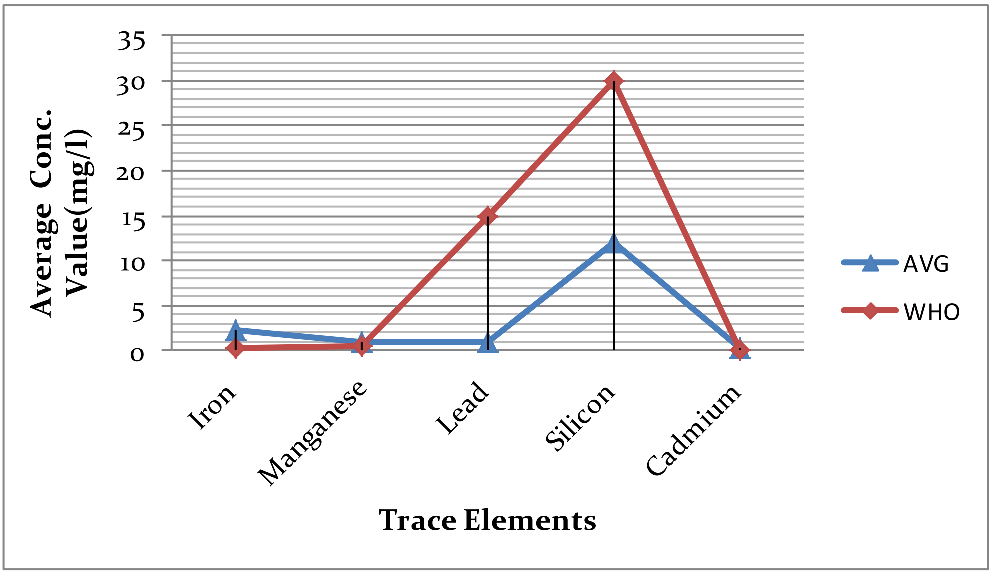


**Figure 3:** Average Values of Trace Element with WHO standard

## 4. Conclusion

The result of the physical parameters indicated that the water samples were fairly safe for consumption and domestic use. However, maximum permissible limit of some trace elements from chemical analysis exceeded WHO recommendation. These higher concentration values of trace elements may be due to lateritic nature of the study area. At greater depth, with reducing conditions, the solubility of Fe-bearing minerals in water increases leading to an enrichment of dissolved iron on groundwater [28-29]. Therefore, it is recommended that a good water treatment plan and process should be encouraged in the locality to have water that will promote good healthy living, and reduce water related diseases.

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